NELSON LEDGE STATE PARK.

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INTRODUCTION.

It occurred to the writer that more should be known by the public of the scenery of Ohio and especially of the parks of the State. Little has been done to bring to the attention of the people the natural beauty and features of scientific interest in the parks. For that reason we hope to stimulate more enthusiasm in the appreciation of the natural wonders of Ohio.

Much credit is due State Forester Edmund Secrest, and other public-spirited citizens for their tireless efforts to preserve the beauty spots and forest lands for the benefit of the public and future generations. Let us hope that the work which they began will be carried to completion in the near future.

The map (Fig. 1), accompanying this paper shows the location of the trails and places in the park. The writer wishes to acknowledge the aid received from his assistants George Crowl and George Yunck of the Geology Department of Wooster College, and Arthur Murray and Malcolm McNutt of Wooster.

HISTORICAL.

Before the coming of the white man, the region in the vicinity of Nelson Ledge was the hunting ground of the Indians. That it was a favorite haunt of the red man is indicated by the fact that many implements have been found in the locality. Cornelius Baldwin, an early settler, who owned the first farm to the south, where the ledge begins, was an ardent collector of Indian relics. Fifty years ago the Baldwin collection was presented to Hiram College where it is on display in the museum.

In 1870 Nelson Ledge experienced a gold rush. It was reported that gold had been discovered in the rock formations. But it was soon learned that the yellow crystals were not gold but iron pyrite, commonly known as "Fool's Gold."

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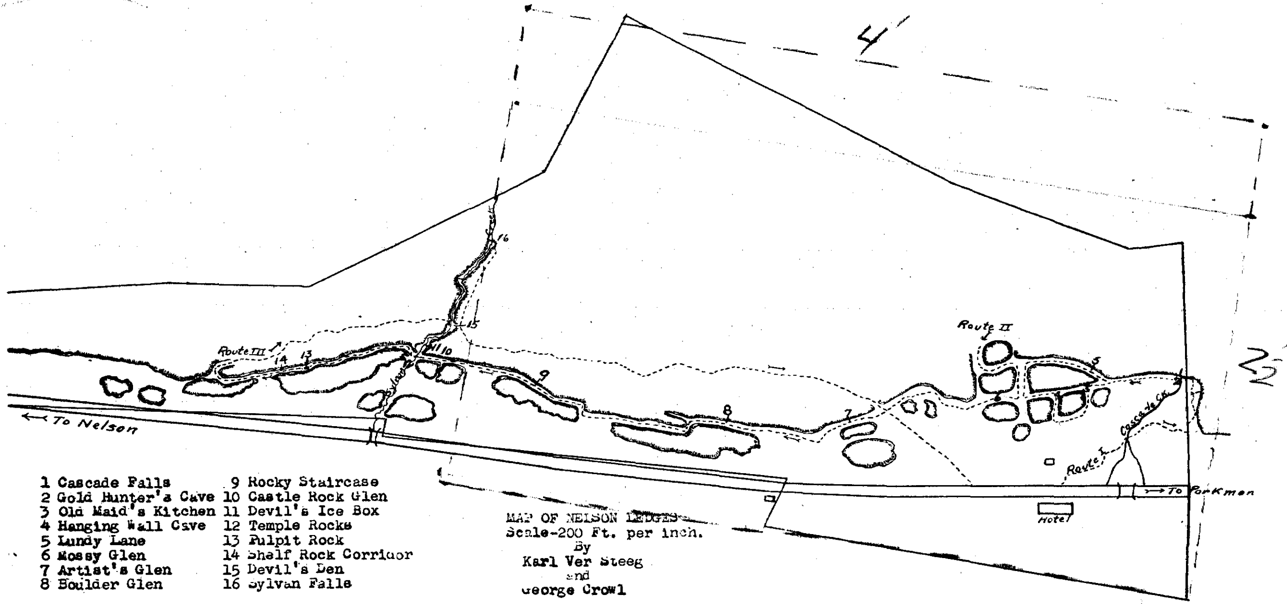

FIG. 1. Map of Nelson Ledge State Park, showing trails, locations and boundary lines.

For many years Nelson Ledge has been known as one of the natural wonders of Ohio. Constant urging by interested parties, who were anxious to preserve it in its natural state, led to its purchase in 1925 as a State park.

LOCATION, DRAINAGE AND TOPOGRAPHY.

Nelson Ledge State Park is located in the extreme northeastern township of Portage County, two and one half miles from the point where Portage, Geauga and Trumbull counties meet. It lies about five miles from Garrettsville and approximately three miles from Parkman, and can be easily reached by paved roads which lead from Cleveland, Youngstown and Akron.

In the broad valley to the east of Nelson Ledge, not far from Cascade Falls Hotel, is located the continental divide. Two streams, Cascade Creek and Sylvan Creek flow through the park; each has a beautiful cascade in its course, and arises on the upland in a glacial marsh, located about a quarter of a mile west of the Ledge. These creeks join to form a tributary that flows northward into the Grand River, which flows from Parkman through a deep, narrow gorge for a distance of about two or more miles, the waters ultimately reaching Lake Erie. To the south of the divide, a stream referred to on the map as Nelson Ditch flows south to join Tinker Creek, the waters of which ultimately flow into the Mahoning River, a tributary of the Ohio.

The State of Ohio comprises two major topographic divisions, the Erie Plain in the northwest, occupying about one-fourth of its area and the Allegheny Plateau in the east and southeast, occupying nearly all the rest of the State. Portage County lies in the northern extension of the Allegheny Plateau in Ohio. This upland is really the western continuation of the plateau, covering New York and western Pennsylvania. It has been deeply trenched by the Grand River and its tributaries on the north, and the Mahoning River on the south.

From Thompson Ledge in Thompson Township, Geauga County, the eastern outcrop of the Sharon Conglomerate, in general, follows a nearly north and south line, with indentations across Thompson, Montville, Huntsburg, Middlefield, and Parkman Townships in Geauga County and Nelson Township in Portage County, when it turns southeasterly across Windham Township. Along this north and south escarpment there are various ledges and glens affording exposures of the Sharon Conglomerate; the best known is Nelson Ledge. Kennedy Ledge, located a mile directly east of Nelson Ledge is considered

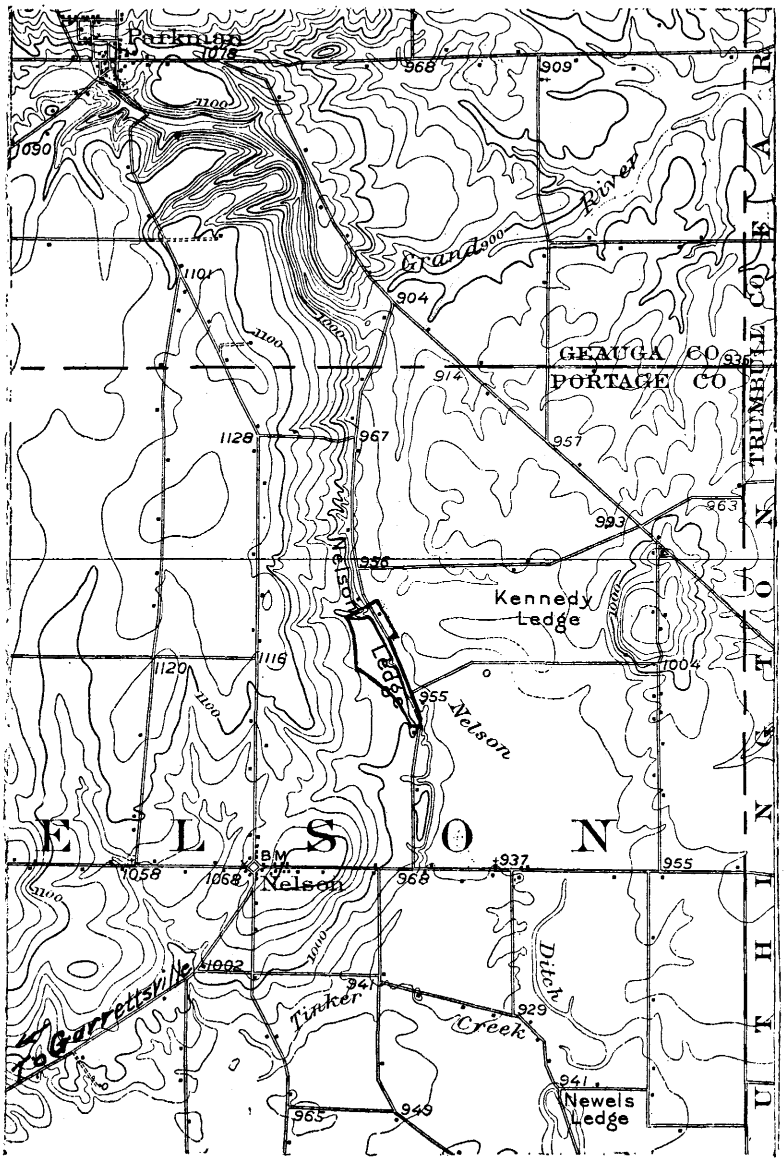

FIG. 2. Section of the Garrettsville quadrangle, showing Nelson Ledge State Park.

an outlier of the Sharon Conglomerate and stands well above the surrounding drift-covered plain.

The accompanying topographic map, a portion of the Garrettsville quadrangle, shows a broad, nearly flat plain lying between Nelson and Kennedy ledges. It is probable that in preglacial time a stream of considerable size occupied this valley. Its present floor displays the characteristic, hummocky topography of the ground moraine. To the east of the town of Nelson and in the vicinity of Nelson Ledge there are broad expanses of marsh-land. Nelson Ledge, a long erosional cliff, bounds the upland on the east and forms a nearly vertical wall for a distance of about 150 feet from the road which parallels its base. The upland to the west of the ledge has an average altitude of about 1,100 to 1,120 feet above sea level, rising to the west. The upland appears to be fairly flat, the rise to the west being gradual. The relief is characteristic of a glacial topography, rolling, with knobs, hollows, flat expanses and marshes here and there. Both Nelson and Parkman are located on the upland at an elevation of about 1,160 feet above sea level. The ascent is rather steep from the lowland to the upland, a rise from an altitude of 900+ to 1,100+ feet, a distance of 200 to 250 feet.

STRATIGRAPHY.

The indurated rocks in Ohio are all of sedimentary origin and of Paleozoic age, ranging from Middle Ordovician to Permian. They have a total thickness of 5,400 to 5,800 feet and comprise limestone, dolomite, shale, sandstone and conglomerate, with beds of rock-salt and gypsum in the middle part of the section and beds of coal and fire-clay in the upper part. The Lower Ordovician and Upper Cambrian are not exposed in the State and they rest on the pre-Cambrian complex made up of metamorphic rocks such as those which appear from beneath the Paloozoic formations in Wisconsin, Minnesota and Canada. Over-lying, and in most places concealing the hard rocks of the northern two-thirds of the State, is a blanket of glacial drift, which in places reaches a thickness of several hundred feet.

In the vicinity of Nelson Ledge the exposed rock formations are sedimentary and were laid down in the Mississippian and Pennsylvanian periods. Glacial drift covers the bed rock in most places but appears to be absent or thin at the Ledge and on the upland immediately to the west. Well-logs indicate that the thickness of the glacial drift in the pre-glacial valley to the east of the Ledge varies from 80 to 120 feet.

The Cuyahoga formation which lies beneath the Sharon Conglomerate at Nelson Ledge belongs to the Waverly Series, a group of formations laid down during the Mississippian period. It consists mainly of shale and is commonly known as the "Cuyahoga Shale" but it contains in addition to shale a considerable amount of sandstone. The upper five or more feet of black or grey Cuyahoga shale are exposed at Nelson Ledge, in Gold Hunter's Cave, located at the foot of Cascade Falls. The Sharon Conglomerate lies unconformably above it. According to Wilber Stout, State Geologist of Ohio, this formation is correlative with the conglomerate at Sharon, Pennsylvania and with the Olean around Olean, New York. Farther south in Ohio it is prominent at Cuyahoga Falls, at the quarries near Massillon, at Glass Rock in Perry County and is at its best in eastern Pike and western Jackson counties in southern Ohio, where its thickness is from 50 to more than 200 feet. It appears to be correlative with the Mansfield of western Kentucky and southern Indiana. The Sharon Conglomerate is well displayed at Nelson Ledge, where it is massive and the pebbles numerous. Some of them are as much as 2½ inches long and 1½ inches in diameter; as large as a hen's egg. In southern Ohio the largest pebbles, occasional ones, are as large as the fist. Usually pebbles the size of a hen's egg are rather uncommon, most of the material being fairly fine. The great majority of pebbles range from one-half to three-quarters of an inch in size at Nelson Ledge. The matrix of the conglomerate is a coarse grained sandstone or grit, in which the pebbles are embedded. Where freshly broken, the sandstone is buff or red in color. The weathered surface is dark brown and where thoroughly oxidized, a bright red color. The conglomerate shows the effects of differential weathering, those beds offering less resistance to weathering forming hollows, and those of greater resistance, forming ridges. In places the pebbles are less numerous and the beds are mainly coarse sand. At Kennedy Ledge, to the east of Nelson Ledge, the conglomerate contains fewer pebbles and they are smaller, on the average. This is evidence that within short distances the nature of the formation changes considerably. Everywhere it shows beautiful cross-bedding, bottomset, foreset and topset beds being common. Lamb[1] believes the Sharon Conglomerate is a stream deposit because of its position, constitution and structure. The pebbles are nearly all white, vein-quartz, occasional ones being rose-quartz or jasper. They are, without exception, well water-worn. The fact that they are all crystalline quartz, such as is found in igneous or coarsely crystalline rocks would indicate that they came from distant sources and not from Ohio or its neighboring states. The nearest coarsely crystalline rocks from which they could have been derived, were, during the Pennsylvanian period, located in the Canadian Shield to the north or the continent of Appalachia to the east. Studies made by geologists[2] indicate that the Sharon Conglomerate was laid down in troughs in the old Mississippian floor. It appears to be of marine origin, laid down in what are in some instances, broad valleys. The material apparently filled these valleys with thicknesses of from 100 to 200 feet of conglomerate. The Sharon coal, commonly known as the number 1 coal, was laid down above it. The older authorities attributed the pebbles to quartz veins in old Appalachia, but Hyde and Stout[2] tracing the streams through the short distance they are exposed along the outcrop, have the idea that they came from the northwest, from the southern part of the Canadian Shield. However the question is not a settled one and requires more work in the field for its solution.

The irregular, sharp contact of the Sharon Conglomerate with the Cuyahoga shale can be seen in Gold Hunter's Cave. Here the conglomerate appears to fill hollows on the undulating, eroded surface of the Cuyahoga. A careful study of the base of the Sharon Conglomerate, which constitutes the roof of the cave, reveals in places, pieces of flagstone, shale and cobble stones derived from the Cuyahoga, some angular, some rounded and flat and well worn, several inches thick and more than a foot long, lying in all directions and mixed with sand and pebbles.

The Sharon Conglomerate is reported to be 75 feet thick by Lamb[3] at Nelson Ledge. The writer measured its thickness at Cascade Falls with a tape and found it to be 45 feet. At the

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[1]Lamb, G. F. Journal of Geology, Vol. 19, pp. 104–109, 1911.

[2]Hyde, J. E., Stout, W. Personal Communication from Stout.

[3]Lamb, G. F. Idem 1, p. 106.

Devil's Den a thickness of 49 feet was obtained. Prosser[4] reports a thickness of 150 feet based on barometer readings secured at the base of the conglomerate at Nelson Ledge and its highest outcrop on the highway east of the town of Nelson. The thickness varies because of two factors, erosion and the irregularity of the surface upon which it lies.

Economically, the Sharon Conglomerate is used in the manufacture of silica brick. The first silica bricks manufactured in the United States were made from the Sharon Conglomerate near Akron about 1875. Bricks of similar character are being made by the Niles Fire Brick Company of Niles, Ohio, the Ohio Quartz Products Company, Jackson, Ohio and the Portsmouth Refractories Company at Portsmouth, Ohio. Another company utilizing the conglomerate for refractory material is operating at Newels Ledge about three miles south of Nelson Ledge. The sized pebbles are also used extensively in water filtration plants and the fine material for sand blasting and foundry purposes.

GEOLOGICAL HISTORY[5].

For the benefit of those not familiar with the geological history of Ohio, a brief summary is included here Nothing is known of the rocks which underlie the Paleozoic strata of Ohio and little is known of the pre-Cambrian history. During the Paleozoic era the sea advanced and retreated over Ohio and sedimentary formations were laid down estimated to be over a mile thick. In Silurian time the sea became shallow and parts of it became lagoons, from which evaporation was rapid and in which mineral matter was concentrated and deposited as thick beds of gypsum and rock salt. At the close of Silurian time the Cincinnati arch in western Ohio, eastern Indiana and central Kentucky was uplifted as a broad geanticline. Toward the close of the Paleozoic era the seas shallowed in Ohio and during the Mississippian period the Waverly series of formations were laid down. They include the Bedford shale, Berea sandstone, Sunbury shale, Cuyahoga and Logan formations. Above the Logan formation and not included in the Waverly group is the Maxville limestone. At the close of the Mississippian period the seas withdrew and a

[4]Prosser, C. S. Bulletin 15, Fourth Series, Ohio Geol. Survey, p. 292.

[5]Based on Columbus Folio, No. 197.

long period of erosion ensued. The Maxville and Logan formations, if they extended over northern Ohio were completely removed by erosion and valleys from 100 to 200 feet deep were carved in the Cuyahoga formation. The unconformity marking the contact between the Cuyahoga Shale and Sharon Conglomerate of the Pennsylvanian is one of the most widespread and represents a period of erosion during which hundreds of feet of material may have been removed. During the Pennsylvanian period, eastern Ohio lay nearly at sea level, being at times submerged and receiving thin marine deposits and at other times being land, covered with vast swamps in which flourished the plants whose remains formed beds of coal. These conditions continued well into the Permian period, when the sea finally disappeared, and has never returned. At the end of the Paleozoic era a vast area which had been sea was uplifted into the Appalachian Mountains. During the Mesozoic era the Appalachian region including Ohio was beveled by erosion. This peneplane has been removed by erosion and another developed during the Tertiary era. The latter is represented by the upland in eastern and southeastern Ohio at an altitude ranging from 1,200 to 1,300 feet. This erosion surface, called the Harrisburg peneplane[6], was uplifted and dissected in Tertiary time and another surface, called the Worthington peneplane[5], developed at an average altitude of 1,000 to 1,100 feet.

In the Quaternary era great sheets of ice formed continental glaciers and spread outward from centers of accumulation in Canada. Four or perhaps five ice sheets successively invaded the territory west of the Mississippi River and at least two of them, the third or Illinoian and the last or Wisconsin, entered Ohio. At the time of greatest extent the ice covered two-thirds of the State, on the southwestern corner reaching a little beyond the Ohio River. As the ice advanced it eroded the surface more or less, accentuating the relief in some places and obliterating it in others. It picked up and carried along a great quantity of stones, clay and sand, which was in part carried away by the streams as outwash and in part deposited by the melting ice. The mantle of glacial drift left by the ice is in places several hundreds of feet thick. In areas of slight relief it has formed an entirely new surface, which bears little

[6]Ver Steeg, Karl. Erosion Surfaces of Eastern Ohio, Pan-American Geologist, Vol. LV, March-April, 1931.

or no relation to the bed rock topography, for it filled and obliterated many of the pre-glacial valleys in the old surface. During each interglacial epoch as well as since the final disappearance of the ice, a new system of drainage was established on the new surface and more or less dissected it. The preglacial drainage of the Allegheny Plateau was northwestward to the Erie Plain, but as the ice margin retreated across the State from south to north, the drainage from the melting ice at first escaped freely to the south and dissected the surface sufficiently to determine the direction and character of the drainage of the present time. After the ice had left the high ground and its margin was receding down the northerly slope to and across the Erie Plain, the drainage no longer escaped freely southward but was ponded in a series of small lakes between the ice edge and the plateau. At first these lakes discharged southward through notches in the plateau, but as the ice melted back their levels were lowered and broadened out and united to form a series of lakes that preceded the present Lake Erie. The divide between the drainage to the Ohio and that to Lake Erie was in part newly established and in part uncovered nearly everywhere along or close to the edge of the plateau. The post-glacial streams have cut down to bed-rock and made gorges in it and at other places have partly cleared out the drift-filled old valleys.

It is probable that the valley to the east of Nelson Ledge was occupied in preglacial time by a tributary which flowed northward to join the old Ohio, a large preglacial stream which flowed through the broad valley leading from Youngstown, Niles and Warren and out through what is now the valley of the Grand River to the Lake Erie lowland. The drift-fill in the lowland to the east of Nelson Ledge is from 80 to 120 feet thick.

ORIGIN AND FEATURES OF NELSON LEDGE.

In the preliminary topics we have discussed the location, drainage, topography, geologic history and stratigraphy of the area. With this background it is possible to proceed with the discussion on the scenic features at Nelson Ledge.

One of the outstanding characteristics of the Sharon Conglomerate are the well-developed joints which break the rock into great blocks. They occur in systems having definite trends. At Nelson Ledge the writer made observations on the direction of a large number of joints and found one system with a trend of N. 35°–40° W. Another system has a direction varying from N. 10° E. to N. 30° E. most of them being N. 20° E. These two systems are nearly parallel to the cliff and are the most important. Another well-developed system runs from N. 60° to 80° W., and a few joints were recorded at about N. 65° to 70° E. There are four systems of joints, two parallel to the cliff and two which meet the others at a high angle. Such systems of widely spaced joints would tend to break the Sharon Conglomerate into huge, angular blocks. The cause for the jointing is attributed to differential stresses produced by crustal movements in the past, shrinking and settling of sediments due to loss of water incorporated in them when laid down, and the weight of the superimposed beds laid down upon them.

The tendency is for an escarpment to recede as a result of erosion. The recession is more pronounced when a hard rock formation, very resistant to erosion is underlain by a softer material. The removal of the weaker substance, commonly shale, from beneath the harder formation, a process of undermining, is known to geologists as sapping. At Niagara Falls, a similar process accounts for the retreat of the falls. At Nelson Ledge the Sharon Conglomerate, a hard, siliceous rock, very resistant to weathering and erosion is underlain by the Cuyahoga shale, five or more feet of which are exposed in Gold Hunter's Cave located beneath Cascade Falls. Here the undermining process has produced a semi-circular cavern about 80 feet long and 35 feet wide. The chief agent of erosion is Cascade Creek; it is evident that the origin of the cave is directly related to the formation of the pothole at the base of the falls. The waters of Cascade Creek, falling a distance of about 50 feet now dashes on a large boulder which fell from the cliff above and at present partly blocks the entrance to the cave. Although this rock breaks the force of the water to some extent, during heavy rains a great volume of water whirls around in the cave and further undermines the cliff It is probable that the fall of the rock is recent and that most of the undermining took place prior to its fall. Nevertheless the process is quite active at present. From the back of the cave and midway, there is a stream of water which issues from an opening in the rock. One can hear the roar of falling water somewhere to the rear and not far from the opening.

The water is falling from above through an enlarged joint in the Sharon Conglomerate. Here we have another example of how the undermining process is accomplished. The softer shale is thus removed by the work of water flowing along enlarged joints. That this process is effective can be observed at the Devil's Den and in the narrow gorge or cleft immediately to the west of it. That the undermining process takes place to some extent by underground water flowing along joint planes is further suggested by the numerous hollows and sags on the upland to the west of the cliff. Here for several hundred feet back from the escarpment the upland has the appearance of an undermined area.

There is another point in the park where similar processes of erosion have produced a cave and a deep narrow gorge. A stream, Sylvan Creek, heads in a swamp to the west of the State Park area, and after flowing eastward to a point about 50 feet east of the park boundary, dashes over Sylvan Falls into a deep narrow channel. This gorge, about 50 feet deep, has been cut along the joint planes and has an angular, zig-zag form, the result of excavation along two joint systems which meet at an angle; one system has a northwest and the other a northeast trend. So narrow is the gorge that at a point just west of the Devil's Den it is little more than a cleft in the rock, in some places not more than two or three feet wide and standing at an angle of about 70 degrees. Similar features have been produced at the Dells of the Wisconsin at Kilbourn, as a result of streams following the joints in the Potsdam sandstone of upper Cambrian age. There the Wisconsin River and its smaller tributaries have followed the joints, forming post-glacial gorges, in some places extremely narrow and angular.

At the Devil's Den, Sylvan Creek has been very effective in undermining the conglomerate. As a result the rock has fallen in and been further removed by weathering and water action. One large block at the Devil's Den, which has been undermined, is tilted and has dropped down a distance of about three feet, forming a scarp; at other points in the park where undermining has allowed blocks to settle, scarps are present. In several instances two blocks have fallen so that the tops rest together while the bases are detached forming grottoes such as Hanging Wall Cave and Old Maid's Kitchen. There are also not infrequent caves formed by joints where

PLATE I.

FIG. 3.
Cascade Falls.

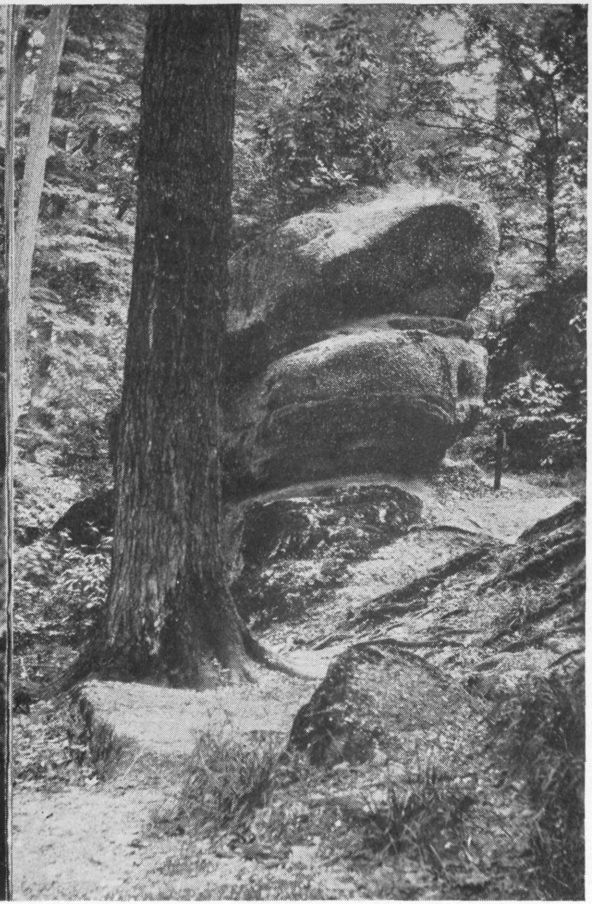

FIG. 4.
View along the trail. Sharon conglomerate well displayed.

they are roofed over by the upper layers, an excellent example being Shelf Rock Corridor. In many cases the blocks are tilted away from the cliff, producing a wide crevice at the joint plane where the break occurred. To the east of the Devil's Den there is another grotto through which flows Sylvan Creek. It measures about 40 feet from end to end and is called the Devil's Ice Box because of the low temperatures which exist, even during the warmest days of summer. Here the creek has undermined the conglomerate and produced a cave. It requires no stretch of the imagination to picture the collapse of the roof and the tilting of the block, a process which doubtless has taken place many times in the past. It is quite apparent that the undermining process has been very effective along the creeks. The great boulders are much more numerous at Cascade Falls and along Sylvan Creek, east of the Devil's Ice Box. It is obvious that the undermining process is at present taking place far back from the cliff along Sylvan Creek. The greater effectiveness of the streams in the undermining process accounts for the greater number of detached blocks of conglomerate along them. The two systems of joints, which parallel or nearly parallel the ledge face or scarp, facilitate the breaking of the blocks from the ledge after the undermining process has accomplished its work. At some distance back from the cliff, possibly a few hundreds of feet, the water is finding a way of escape by draining downward through the joint planes in the conglomerate. It is probable that the joint planes have been much enlarged by weathering and undermining. The surface is quite hummocky with many shallow depressions reminding one of an undermined area.

The most picturesque localities in the park are at those places near the creeks where the undermining process has produced many isolated blocks of rock and deep, narrow gorges. The two most interesting spots from both scenic and scientific stand-points are at Cascade Falls and along Sylvan Creek from Sylvan Falls to Temple Rocks. The picturesque trails along which are found the glens, narrow gorges and grottoes, are marked off into three routes, which combined, measure more than a mile in length.

A common misconception by the layman concerning the processes which have operated to produce the fallen blocks of rock is that a great earthquake took place at some time during the past to produce the assemblage of huge boulders standing at all possible angles. This is not correct, for as has been pointed out in the previous discussion, a slow process of undermining by weathering and erosion is the sole cause. Some day the roof of Gold Hunter's Cave will collapse. The downward movement might be a sudden one, the impact producing a small earthquake. Minor earthquakes occur occasionally in regions where caverns or underground passages are present in limestone areas. The collapse of the roof or the fall of masses of rock from above to the floor of a cave may be the cause. Small earthquakes have occurred in the vicinity of Niagara Falls, when great blocks of undermined limestone have fallen from the brink of the falls to the gorge below.

It has been suggested that a stream to the east of Nelson Ledge accomplished the undermining responsible for the great blocks of conglomerate which lie below the cliff. It is not necessary to account for them in that manner, for it is obvious that the processes of weathering and erosion by running water are very active at present in producing the features of the park. Furthermore it is impossible to account for the undermined areas back from the ledge face by the action of a stream to the east.

A process not given much consideration so far, is that of weathering. The joints allow the ready movement of water downward from above. This water which carries oxygen and carbon dioxide, and direct contact with the air itself, accomplish changes. As a result the rock undergoes a process of chemical disintegration. Mechanical weathering takes place when the water, absorbed by the rock and filling the cracks, freezes. The expansion causes the rock to break, repeated freezing and thawing producing mechanical disintegration. By chemical and mechanical processes of weathering the joints are gradually enlarged. In some cases the debris which has fallen into the crevices from the walls above, has nearly filled them. It is probable that the hollows on the upland, back from the face of the ledge, are due mainly to the enlargement of the joints by weathering. The Sharon Conglomerate weathers differentially, the more resistant beds standing out conspicuously. One occasionally sees numerous, small, nearly circular, shallow hollows in the conglomerate where it has been exposed to weathering. The Sharon Conglomerate has a tendency to weather with rounded instead of sharply angular outcrops.

Another weathering process which has aided in rock disintegration is the result of plant growth. There are a number of large trees in the park whose roots occupy the narrow spaces or joints between the blocks of conglomerate, gradually wedging them apart. One wonders how the trees can live when their roots extend down into what appears to be barren rock. Such trees are found at a number of places in the glens such as Lundy Lane and others. In some cases the trees cling to the vertical walls of the conglomerate. Mosses, ferns, and lichens where there is sufficient moisture, cover the walls with a mass of growth. Because of the dense foliage which shades the ledge the evaporation is small, and these plants flourish in the cool, damp glens. They absorb moisture and further aid the process of weathering.

One sees in Gold Hunter's Cave and in other parts of the park, a brilliant, yellow material commonly known as ochre or limonite ($Fe_2O_3.3H_2O$). In the cave it is being precipitated from the waters of the spring which issues from the back wall of the cave. The spring doubtless obtained its iron from the Sharon Conglomerate through which it has flowed or percolated. Wherever the water issues from the conglomerate and stands for any length of time, an iridiscent scum, resembling oil forms on the surface. This scum is produced by oxidation at the surface of the water, where the iron in solution comes in contact with the oxygen in the air. Hanging from the roof of Gold Hunter's Cave are numerous, short, rounded stalactites of limonite. It is possible that the ochre results from the weathering of iron pyrite present in the Sharon Conglomerate. The water from the conglomerate, although it contains a small percentage of iron in solution, is soft, and contains little carbonate of lime and other impurities which require soap for softening.

Bacteriology.

A new and reset edition of a standard text-book on bacteriology. The older editions were among the best of their kind, and the new edition seems to live up to the high standard previously set. New material in this edition includes thorough discussions of the bacteriophage, of the role of bacteria in the arts and industries, and of the practical applications of this subject especially in regard to milk, butter and water. Other chapters have been entirely rewritten.

The same clear style and thorough treatment that characterized the older editions are apparent in this, and it will undoubtedly continue to receive the same enthusiastic welcome which it has enjoyed in the past.—S.

Elementary Bacteriology, by Joseph E. Greaves and Ethelyn O. Greaves. 535 pp., 12 mo. Philadelphia and London, W. B. Saunders Co., 1932. **$3.50.**